Carbon nanofiber-PMMA composites processed by solvent: Effect of amino-functionalization

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Carbon nanofibers (CNF) are a fibrilar material with aspect ratio above 10. They are produced from a gas phase carbonaceous precursor (like CO, natural gas, acetylene, benzene…), through high temperature catalytic decomposition, using a transition metal (Fe, Co, Ni...) in an elemental state as catalyst. One of the most important applications of carbon nanofibers is as fillers in discontinuous-fiber type composites, for either reinforcement or to achieve electrical conductivity. In order to be suitable in their applications, carbon nanofibers must be well dispersed in the whole matrix. Otherwise, mechanical properties would fall drastically due to ease of the fracture.

In addition, to obtain a composite material with improved mechanical properties, it is required to achieve a good contact between carbon nanofibers and polymer, with adequate wettability. It is usual to do functionalisation treatments that modify nanofibers chemical surface to favor covalent binding between matrix and nanofibers.

In this work an amorphous thermoplastic polymer like poly-methylmethacrylate (PMMA) is used to improve its electrical properties by adding CNFs and to study the possible improvement of mechanical properties and dispersion by using either pristine or nitrogen-functionalized CNFs. Present work was carried out using GANF carbon nanofibers (Grupo Antolin, Spain) and they were mixed with the polymer by dispersing them with the aid of solvents.

Dispersion grade was studied in two levels: microscopic and nanoscopic scale. The dispersion at microscopic scale was studied by optical microscopy, measuring the size of CNFs agglomerates in 50 fields of 200 μm wide and 150 μm high each one, which is a total explored area of 1.5 mm^2. At nanoscale, 12 fields of 30 μm^2 each one were explored by TEM, which makes up a total area of 360 μm^2. Area in nanodispersion measure is 4000 lower than area in microdispersion, so objectives of nanodispersion are different from the microdispersion ones. Figure 1 shows TEM micrographs of two samples with a different grade of dispersion.

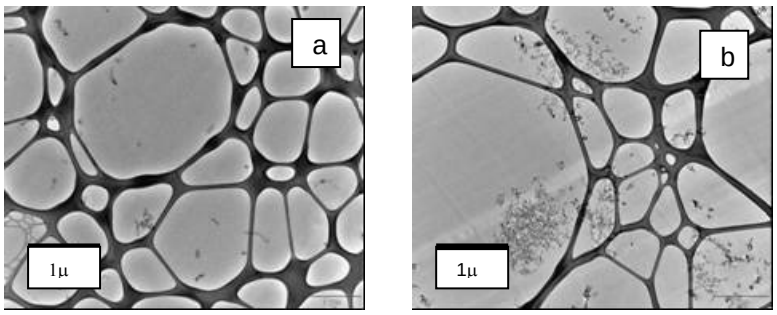

Figure 1. Nanodispersion: a) fibers are well dispersed, and there are not big agglomerates; b) nanodispersion is worse than dispersion in case a).

Finally, it was studied if CNFs improve mechanical properties of PMMA and the importance of covalent binding with the matrix. It was shown that amino-functionalisation improves interaction of CNFs with PMMA, so it was checked if that had a real effect on mechanical properties by comparing with mechanical properties of non-functionalisated CNFs composites.